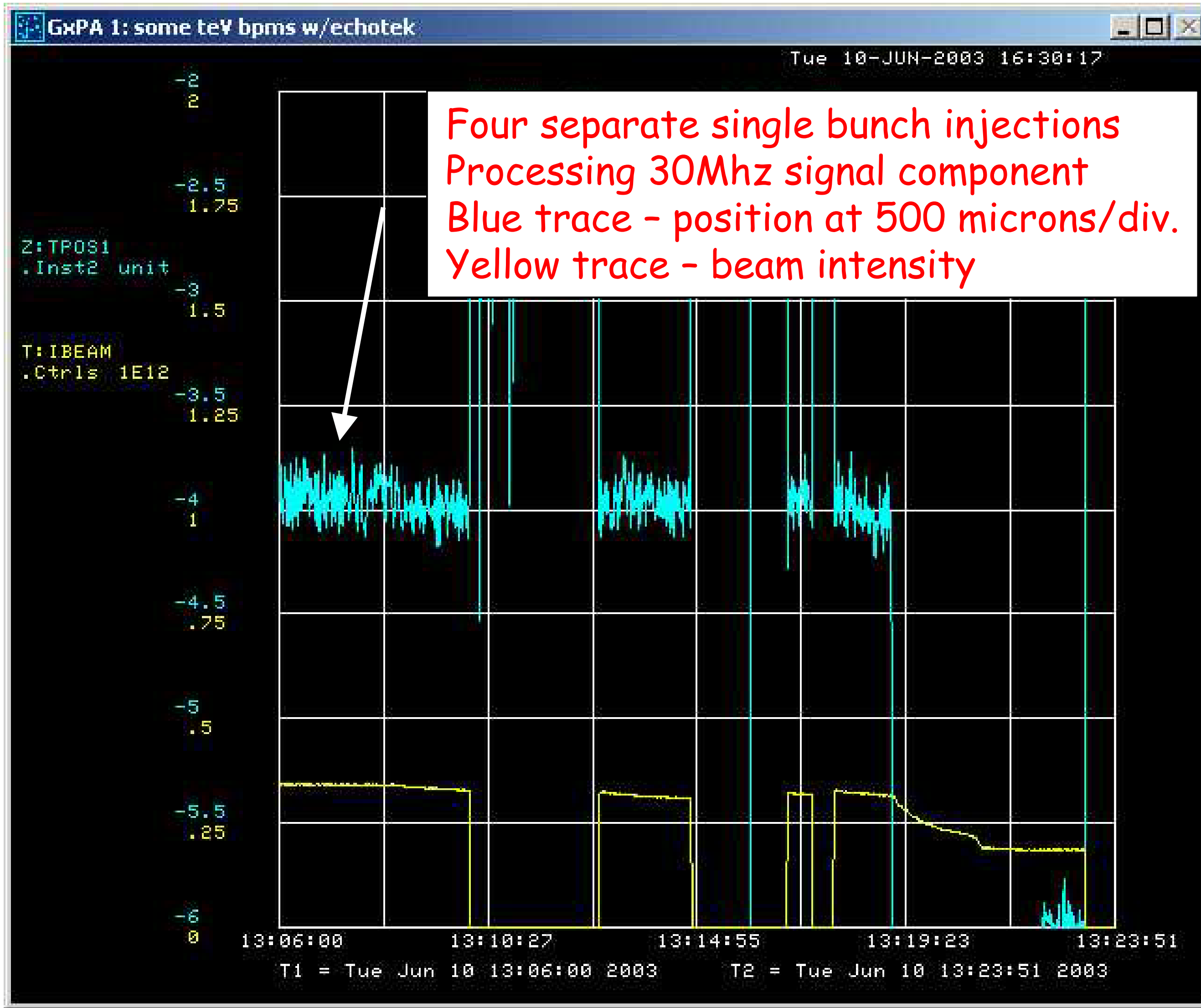
Summary

Status, Motivation, and Directions

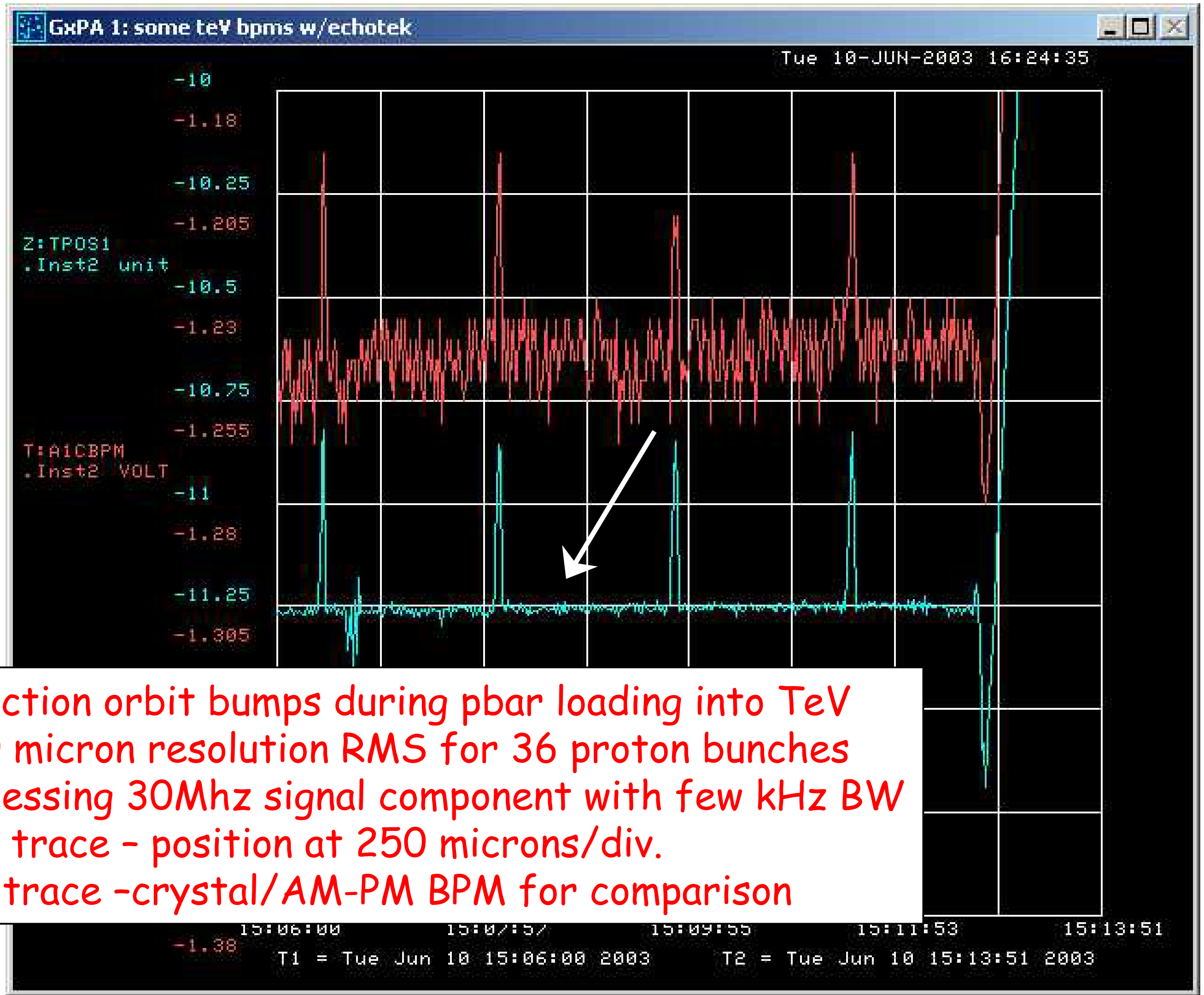
Summary_1 - Where We Stand

- Available, engineered hardware solutions indicate a path that utilizes digital down-conversion signal processing in an under-sampling regime
  - Performance of an under-sampling system has yet to be demonstrated in the Tevatron
  - Two systems (Recycler EchoTek and DSR) are being readied to that end
- We assume that frequency domain de-convolution of p and pbar signals is possible
  - This is not guaranteed and has yet to be demonstrated
- 14 bit digitizer/down-converter resolution performance has been demonstrated in a system operating on 30 MHz TeV signals (no under-sampling)

~35 Micron RMS Single Bunch Resolution



Crystal BPM Comparison During Pbar Load (Store 2671)



Injection orbit bumps during pbar loading into TeV
<~10 micron resolution RMS for 36 proton bunches
Processing 30Mhz signal component with few kHz BW
Blue trace – position at 250 microns/div.
Red trace –crystal/AM-PM BPM for comparison

Summary$_2$

- Cables for pbar signals have been readied during recent shutdown
- Efforts to specify and design the trigger-timing subsystem and built-in monitoring, testing, and calibration functions have yet to begin
- Detailed system and support software specifications are yet to be considered

Summary$_3$

- The system as conceived <u>will not</u>:
  - measure injection first turn except for first injected bunch or un-coalesced bunch train
  - measure turn-by-turn positions with both protons and pbars circulating
  - support bunch-by-bunch measurements in general (except possibly turn-by-turn with only protons or pbars circulating)
  - offer continuous turn-by-turn processing rates at the front-end as the present system does

And so …

- Remember the Objectives
  - Maximize integrated luminosity over the next 5 years
    - What is better in 20 months may be worse than what is good in 10 months
  - Provide Tevatron with a serviceable and maintainable if not optimal BPM system for what may follow Run II
- And the Requirements
  - First turn Flash robustness (avoid critical timing set-ups)
  - Measure pbars in the presence of protons in a way that does not compromise the proton measurement
  - And, more importantly, measure proton orbits accurately throughout Collider cycle with proton/pbar intensity ratios as low as 2:1
  - Provide post-mortem closed orbit data buffers

And …

- Remember the Reality
  - The critical resource for the entire Run II plan is engineering talent with accelerator physics and operations insight (or vice versa) (to wit: vital aspects of this conceptual design are yet to be addressed!)
  - TeV BPMs represent only one piece (and in fact only one of the BPM systems) of the effort required to complete the Run II luminosity upgrade plan
  - Yet it is a large scale effort
    - Replacement of system in operational accelerator
    - 1000 precision measurement channels
    - Distributed in 24+ buildings around 4 mile ring

In the big picture …

- The Tevatron BPM system does not live in nor will it be upgraded in isolation
  - The corollary of a Tevatron hardware platform choice is that it will become the default choice for Run II Plan BPM upgrades in MI and Transfer Lines; a total of ~300 additional BPM locations
  - Impact of build/buy decision is multiplied beyond the scope of the Tevatron system
  - The machinery that builds the TeV system must be kept running to accomplish these other systems; we cannot support building a new project group for each system
  - The NUMI beamline BPM system is on the same "need by" schedule as the Tevatron
  - A 53MHz under-sampling solution has implications for MI and Transfer Lines where 2.5MHz signals must also be observed

On the technical side …

- Risks in this conceptual design
  - Frequency domain p/pbar signal de-convolution
  - Trigger/timing system robustness
  - Time to switch modes - TBT or Flash to Closed Orbit, dead time of circular buffer
    - Has not been investigated in detail for either DSR or Echotek solution
    - May be key difference between Recycler Echotek board and modified Echotek board

On the technical side …

- Tasks requiring immediate attention
  - Quantitative demonstration of the viability of the frequency domain p/pbar signal de-convolution with real signals in the Tevatron
  - Conceptual design, specification, and detailing of timing and triggering plan and components
  - Conceptual design, specification, and integration of built-in monitor, test, and calibration sub-systems with minimal impact on position measuring performance (analog switches are likely key components)
  - Quantifying the overhead, dead-time, inherent in mode switching from flash and/or turn-by-turn to closed orbit
  - Increasing the number of people with skills and experience in ACNET VME front-end programming and BPM (and other) board driver programming

On the schedule/resource side …

- A near-term hardware platform decision will eliminate that component from the critical path!
  - That decision should not distract resources needed to address the numerous then-critical system issues.
- Schedule Risks
  - Seeking the ideal solution
  - Underestimating the total effort required to complete the project
  - Unavailability or over-commitment of key human resources
- Concerns
  - Actual commitment of adequate engineering talent with accelerator physics and operations insight (or vice versa)

On the schedule/resource side …

- A system might be ready by October if and only if key “accelerator wise” resources are committed to lead the willing contributors and to make sound, speedy, and “eyes open” decisions when there may not be right answers

The Plan

- We intend to pursue the modified EchoTek (EchoTek2) solution
  - At a cost of ~1M$ (over all Run II BPM systems)
  - At the benefit of freeing individuals who have other key responsibilities in this or other Run II projects from supporting down-converter board production, testing, trouble-shooting etc.
- Given an EchoTek solution, the Recycler BPM system should be the example and starting point for front-end software
- Immediately turn full attention (except board procurement effort) to the tasks identified a few slides earlier

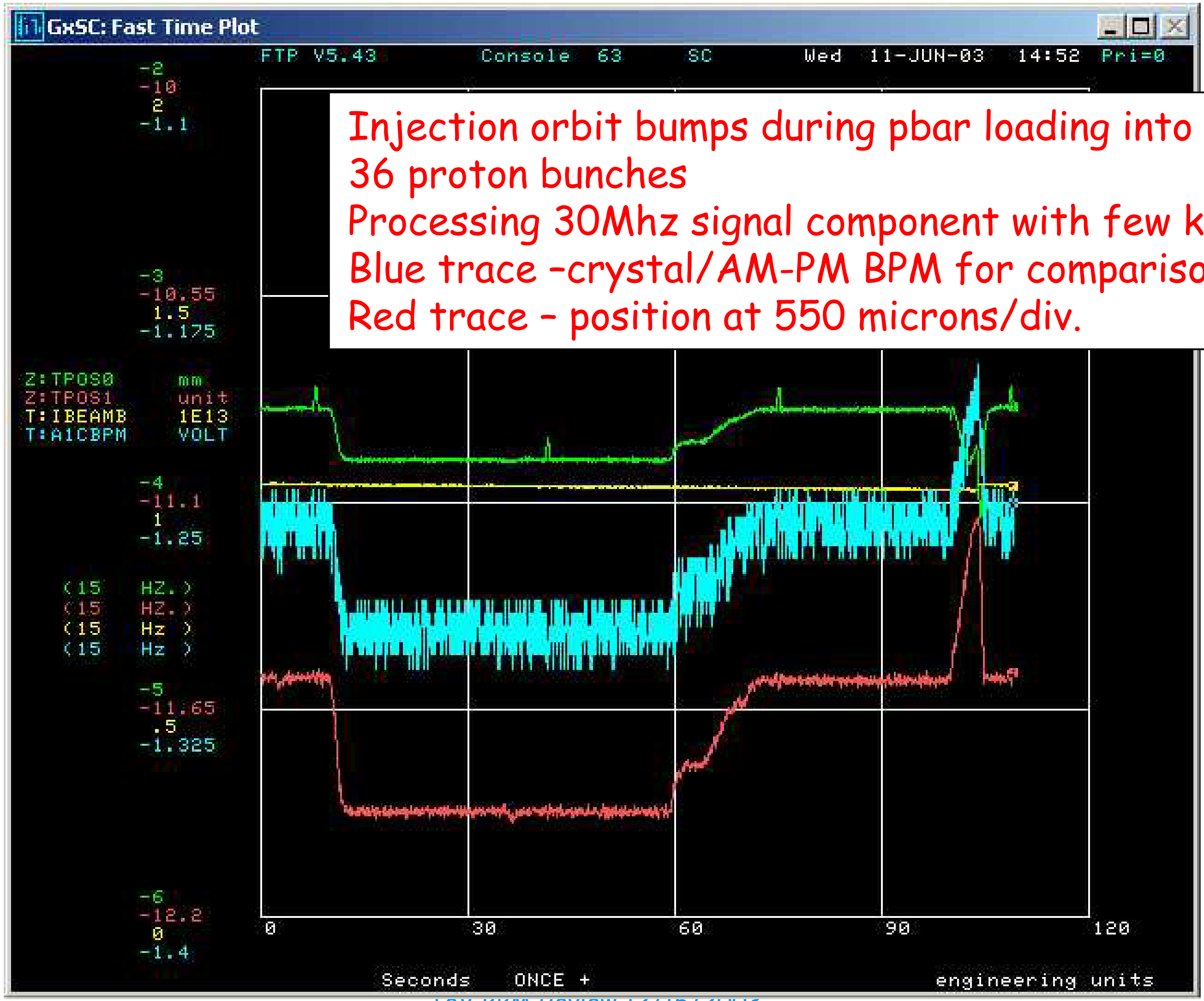
Conclusion

- Damper board
  - can continue to help us with p/pbar signal de-convolution studies
  - should continue to be developed at its own pace as a general purpose high-speed solution
- RF department resources that might have guided down-converter production, testing, and trouble shooting can yet make key contributions to vital project aspects including:
  - analog filter specification, procurement, and acceptance test development
  - digital processing optimization
  - analog calibration circuit considerations

- Everyone who has to this point given time, support, and input offering and urging considerations of hardware solution alternatives are sincerely thanked and urged to remain interested and stay tuned.

Backup slides

Wobbles During Pbar Load #2673



Injection orbit bumps during pbar loading into TeV
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Blue trace –crystal/AM-PM BPM for comparison
Red trace – position at 550 microns/div.

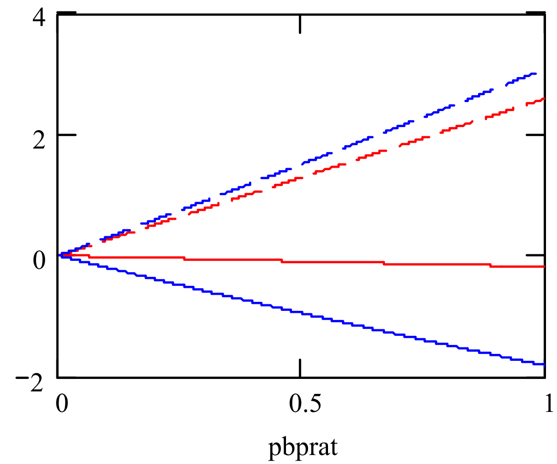
Pbar contamination of Protons

perr(1, pbprat, − 1, .1, .1, 0)

perr(1, pbprat, − 1, .1, − .1, 0)

perr(10, pbprat, − 10, .1, .1, 0)

perr(10, pbprat, − 10, .1, − .1, 0)



$\mathrm{pberr}(\mathrm{pos}_p, \mathrm{pbprat}, \mathrm{pos}_{pb}, \mathrm{ct}_a, \mathrm{ct}_b, \mathrm{ctps})$

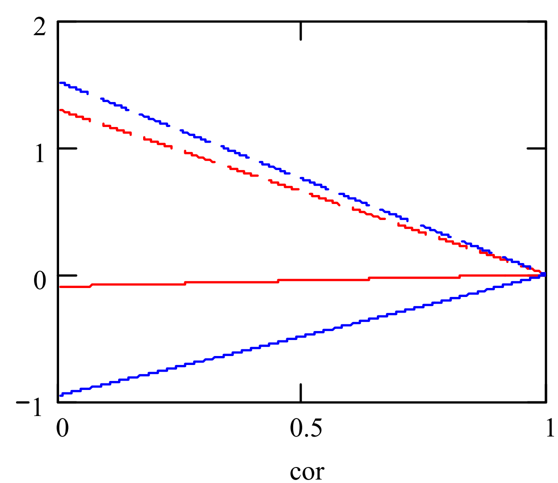
$\mathrm{perr}(\mathrm{pos}_p, \mathrm{pbprat}, \mathrm{pos}_{pb}, \mathrm{ct}_a, \mathrm{ct}_b, \mathrm{ctps})$

perr[1, .5, − 1, .1·(1−cor), .1·(1−cor), 0]

perr[1, .5, − 1, .1·(1−cor), − .1·(1−cor), 0]

perr[10, .5, − 10, .1·(1−cor), .1·(1−cor), 0]

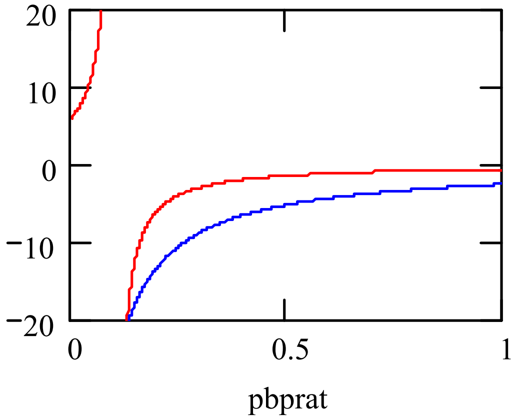
perr[10, .5, − 10, .1·(1−cor), − .1·(1−cor), 0]



Pbar Errors

pberr(1, pbprat, − 5, − .1, − .1, 0)

pberr(1, pbprat, − 5, − .1, .1, 0)



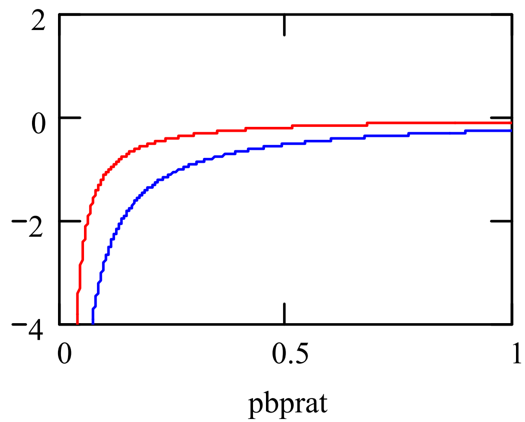
Correction phase matters!!!

$$\mathrm{pberr}\left(\mathrm{pos}_{p}, \mathrm{pbprat}, \mathrm{pos}_{pb}, \mathrm{ct}_{a}, \mathrm{ct}_{b}, \mathrm{ctps}\right)$$

$$\mathrm{perr}\left(\mathrm{pos}_{p}, \mathrm{pbprat}, \mathrm{pos}_{pb}, \mathrm{ct}_{a}, \mathrm{ct}_{b}, \mathrm{ctps}\right)$$

pberr(5, pbprat, − 5, − .01, − .01, 0)

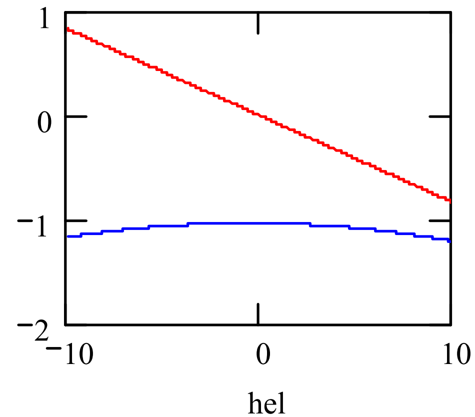
pberr(5, pbprat, − 5, − .01, .01, 0)



Tough to fix even at 25% pbars

$\mathrm{pberr}(\mathrm{hel}, .25, -\mathrm{hel}, -.01, -.01, 0)$

$\mathrm{pberr}(\mathrm{hel}, .25, -\mathrm{hel}, -.01, .01, 0)$



$\mathrm{pberr}\left(\mathrm{pos}_{\mathrm{p}}, \mathrm{pbprat}, \mathrm{pos}_{\mathrm{pb}}, \mathrm{ct}_{\mathrm{a}}, \mathrm{ct}_{\mathrm{b}}, \mathrm{ctps}\right)$

$\mathrm{perr}\left(\mathrm{pos}_{\mathrm{p}}, \mathrm{pbprat}, \mathrm{pos}_{\mathrm{pb}}, \mathrm{ct}_{\mathrm{a}}, \mathrm{ct}_{\mathrm{b}}, \mathrm{ctps}\right)$

$\mathrm{pberr}[10, .25, -10, -.1\cdot(1-\mathrm{cor}), -.1\cdot(1-\mathrm{cor}), 0]$

$\mathrm{pberr}[10, .25, -10, -.1\cdot(1-\mathrm{cor}), .1\cdot(1-\mathrm{cor}), 0]$